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Post exercise massage: Effects on next day performance following heavy lower body resistance training

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POST EXERCISE MASSAGE: EFFECTS ON
NEXT DAY PERFORMANCE FOLLOWING
HEAVY LOWER BODY RESISTANCE TRAINING

A Thesis
Submitted
in Partial Fulfillment
of the Requirements for the Designation
University Honors

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University of Northern Iowa
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Abstract

The purpose of this study is to determine whether post-exercise massage improves next-day performance on an isometric peak force test after heavy lower body resistance training when compared to a placebo control of ultrasound at zero intensity. This was tested using students at the University of Northern Iowa who had been involved in a resistance training program over the past six months. The importance of this study is that if post-exercise massage improves recovery, even after a difficult resistance training day the athlete will still be able to perform at a high level so resistance training bouts can be more intense each day necessary. Having more intense daily exercise bouts will lead to an increased overall training so over time, more advances in conditioning, skill, and performance can be reached. The results of this study were inconclusive, but revealed a number of suggestions and ideas for future research following the same plan to reveal whether post-exercise massage has a true benefit for next-day performance.

Keywords: Massage, Isometric Pull, Recovery, Force Production

Post-Exercise Massage: Effects on Next Day Performance Following Heavy Lower Body Resistance Training

Introduction

In a day where the difference between first and third place can be determined by thousandths of a second and pressures to win are greater than ever, athletes are always looking for a way to improve their performance. Massage is known to have psychological benefits on perceived recovery, but the debate remains whether post-exercise massage can reduce recovery time and improve performance for athletes (Weerapong, Hume, & Kolt, 2005).

Various types of modalities have been studied to test their benefit on athlete recovery including saunas, heat therapy, cold therapy, compression garments, stretching, active recovery, and electric stimulation (Barnett, 2006). To date, none of these studies have shown conclusive evidence that any of these modalities improve the mechanisms of recovery that have been tested. However, the research methods used may not tell the whole story. There has been research testing recovery from high intensity exercise using mean power, max power, blood lactate, fatigue index, and heart rate as measures of recovery one week after an intervention (Robertson, Watt, & Galloway, 2004). This study produced no clear difference in any of the measured areas except fatigue index pointing largely to the psychological benefits of massage. In this study the use of an ultrasound control adds a test of the psychological belief in recovery because these participants are not receiving any true treatment. In addition, the research available does not use resistance training recovery and performance as the measure of massage effectiveness.

In general, the studies that have been conducted in the past measuring the effectiveness of massage on recovery focused on intense exercise instead of resistance training and used various blood tests and power outputs during the exercise to measure the effectiveness of massage

(Weerapong et al., 2005). Resistance training refers to weight lifting through power and strength lifts using either body weight or additional weight. Recovery after resistance training is important because today's athletes thrive on power strength. Much of this strength and power is developed through resistance training programs along with agility, conditioning, and sport specific skill work (Kravitz, 1996). The benefits of resistance training can be seen simply by comparing the Olympics of the 1950s to today and seeing that the athletes of today are much more powerful and stronger than their counterparts from 50 years ago. This is because of the advances in strength and conditioning science. Allowing athletes to undergo this training while possibly improving their recovery as measured by next-day performance has implications of even greater performances and more time to work on sport specific skill because the rest time necessary is decreased.

Therefore, this study will use a 24 hour post-resistance training performance on an isometric peak force test to determine the effectiveness of post-exercise massage. Recovery in this context refers to the body's ability to get back to pre-exercise status in terms of lactate levels in the muscles (which historically have been associated with muscular fatigue), healing the micro tears in the muscles, returning to functional range of motion by reducing muscular soreness, etc. Is post-exercise massage a recovery strategy that can help athletes perform better the next day? There is currently no clear evidence supporting the idea that massage can prevent muscular injury, improve recovery, or enhance performance (Weerapong et al., 2005). This is why this massage recovery study can be beneficial to the athletic community. If massage can improve recovery, the data should be able to support that using force production as a means.

This study utilizes next-day force production using a heavy pull on a force plate, known as an isometric peak force test, as the measure of recovery. Standing on a force plate and trying to lift an excessively large amount of weight generate this force (West, Smith, Lambert, Noakes, & St Clair, 2005). Since the weight is too heavy to be moved, the force generated is sent through the force plate and recorded. If massage is proven effective, implementation of this strategy can be helpful to athletes' resistance training day after day. The side effects of daily resistance training can be detrimental to the body if not properly cared for and allowed adequate recovery. Therefore, this paper seeks to determine whether post-exercise massage improves next-day performance on an isometric peak force test after heavy lower body resistance training when compared to a placebo control of ultrasound at zero intensity.

Null Hypothesis

There will be no significant difference between the massage group and the placebo control group in regards to peak isometric force production following a bout of heavy lower body resistance exercise.

Limitations

1. The sample used in this study is a convenience sample and limits the external validity of the study.
2. Sample sizes are limited because the force plate necessary for testing was delayed in its arrival so data was not collected as early and for as long as anticipated.
3. Using a placebo control will be a challenge for the person administering the false ultrasound to keep the person blind to the fact that the ultrasound is turned off.

4. Even though all participants studied were involved in resistance training for the past 6 months, their training ranged in sets, reps, and percentages of 1RM used during this time.

Delimitations

1. Participants must be males or females between the ages of 18 and 25 and must sign given informed consent to be a part of the study.
2. Participants must have been regularly engaged (three times per week) in a resistance training protocol for at least 6 months.

Assumptions

1. Subjects will be free of orthopedic conditions that could affect their performance.
2. Subjects will provide maximal effort during each test.
3. Subjects will provide maximal effort during the lower body resistance training bout.
4. Subjects will not be aware that the ultrasound machine is emitting no sound waves.
5. Subjects will not engage in another heavy bout of activity between the initial testing and the testing 24 hours later.

Definition of Terms

The following definitions are given to provide understanding and uniformity of the terms

1. Absolute Strength- Maximum strength that can be generated by a person as measured by a one-repetition maximum regardless of body mass (Zatsiorsky, 2000. p. 111).
2. One-Repetition Maximum- One-repetition maximum (1RM) procedures will be based off of the National Strength and Conditioning Association's guidelines (Chromiak, 2005).
Briefly, the procedures are as follows: the athlete will be instructed to perform 5-minutes of cycling on a cycle ergometer followed by a dynamic warm-up involving butt kickers,

frankensteins, ankle flips, and knee hugs. Subjects will then be asked to perform 10 repetitions with a light resistance. After a one-min rest period, the load will be increased by 66kg – 88kg and the subject will attempt to complete 3-5 repetitions. After a 2-min rest period, the load will be increased by an estimated, conservative near-maximum load and the subject will be instructed to attempt to complete 2-3 more repetitions. After a 4-min rest period will again be increased again and the subject will attempt to lift the load for one repetition. More weight added or removed depending on whether the subject was successful or not. The greatest weight lifted is recorded as the 1RM (kg).

3. Isometric Peak Force Test- An Olympic bar will be loaded with a weight that each subject will be unable to lift allowing for a maximal isometric contraction. Each subject will attempt to exert a maximal isometric effort against the bar for a two second time period while standing on the AMTI force plate. The bar will be positioned at mid-thigh. The peak force will be recorded as Newtons (N).
4. Lower Body Resistance Training Protocol- Squatting Protocol of Warm-up then Lift

	Warm-up	Lift
Set 1	10 reps @ 30% 1RM	Max 12 reps @ 67& 1RM
Set 2	10 reps @ 50% 1RM	Max 12 reps @ 67& 1RM
Set 3		Max 12 reps @ 67& 1RM
Set 4		Max 12 reps @ 67& 1RM

5. Ultrasound- Ultrasound machines are a modality used by various professions utilizing high or low frequency sound waves. A vibrating crystal in the sound head of the ultrasound wand transmits these sound waves. These waves create a warming effect in

the deeper tissues of the body. Tissue warming, increased blood flow to the treated area and relaxation are the main goals of ultrasound treatment. This increased blood flow has been theorized to help speed the healing of tissue damage. This increased blood flow has been theorized to help speed the healing of tissue damage (Warden & McMeeken, 2002).

6. Cycle Ergometer- A stationary one-wheeled cycle used as an ergometer to measure a person's work output under controlled conditions. The resistance, and therefore work output is controlled by tightening or loosening a flywheel. The cycle ergometer is good for measuring power output, blood pressure while exercising, and overall a better measure of power output independent of weight.
7. Resistance Training- Resistance training is a form of strength training in which each effort is performed against a specific opposing force generated by resistance of some kind. There are different types of resistance training. Isotonic exercises are if a body part is moving against the force. Isometric exercises are if a body part is not moving, but holding against the force. Isokinetic is where the speed of motion is kept constant regardless of the force being applied. Properly performed, resistance training can provide significant functional benefits and improvement in overall health and well-being (Plisk, 2005).
8. Force Production- Force causes mass to undergo acceleration. In the case of an isometric force production, the mass to be accelerated must be greater than the force generated. As the acceleration of a mass increases, the force also increases.

Significance of the Study

The ability to train at a high level of intensity is of extreme importance in athletics. If an athlete can train at a higher level day after day without the negative effects of over-training cropping up to hinder performance, then over a period of time it can be hypothesized that this athlete will make more gains in his or her sport than an athlete who does not have the advantage of high-level training intensity daily. If post-exercise massage is proven to improve next-day performance in an isometric peak force test and recovery, athletes will be able to train harder daily. If post-exercise massage improves recovery, even after a harder workout day the athlete will still be able to perform at a high level so resistance training bouts can be more intense each day. Having more intense daily exercise bouts will lead to an increased overall training so over time, more advances in conditioning, skill, and performance can be reached.

Review of Literature

Overview

The purpose of this study is to determine the effects of post-exercise massage on the ability to generate peak force after heavy lower body resistance training. Several topics have been identified and briefly discussed in the introduction. The following topics will be further developed in the literature review: (a) methods of enhancing recovery (b) massage types, usages, and benefits, (c) effects of massage on recovery, and resistance training, (d) benefits of resistance training, (e) methods of measuring force, and (f) biomechanics of lower body lifts.

Methods of enhancing recovery

Some common methods used to enhance recovery of elite athletes include: massage, active recovery, cryotherapy or cold therapy, stretching, and a combination of these modalities. Studies show that massage can reduce intensity of soreness and tenderness, but not the

unpleasantness of soreness (Barnett, 2006). Active recovery is used as a recovery method, but research is lacking in this area. The only thing that it has been proven is to more rapidly resynthesize glycogen in recovery. Cryotherapy is only scientifically proven to improve recovery when used in addition to light exercise. It also may inhibit training adaptation (Barnett, 2006). Stretching is rarely studied as a recovery strategy. There is no evidence supporting this strategy as an effective recovery strategy. Research has shown that active recovery in addition to other recovery strategies like massage may be more beneficial than one modality alone (Barnett, 2006).

Massage types, usages, and benefits

There are four basic types of massage used in Classic Western or Swedish massage. These include effleurage, petrissage, friction, and tapotement. Effleurage is used to enhance venous blood return and enhance relaxation by stimulating the parasympathetic nervous system. This movement consists of gliding over the skin with a continuous, smooth motion (Tappan & Benjamin, 1998). Petrissage often follows effleurage and is used to mobilize deep muscle tissue and increase local blood circulation. This movement involves lifting, squeezing, kneading, pressing, or rolling the tissues between or under the hands (Tappan & Benjamin, 1998). Friction is used to break up adhesions in the muscle from old injuries and is used by delivering deep penetrating pressure through the fingertips (Goats, 1994). Finally, tapotement is used to stimulate the tissues by mechanical force or the action of reflexes. This is achieved by striking the tissues with various parts of the hand at a fairly rapid rate (De Domencio & Wood, 1997).

Moving forward, the review completed by Weerapong et al. (2005) evaluated four broad theories of why massage can be beneficial. The mechanisms reviewed included biomechanical

effects, physiological effects, neurological effects, and psychological effects. Biomechanical effects mechanism theorized that mechanical pressure on tissues would reduce tissue adhesions, increase muscle compliance, increase joint range of motion, decrease passive stiffness, and decrease active stiffness (Weerapong et al., 2005). Physiological effects mechanism theorized that changes in the tissue or organ involved would result in increased muscular blood flow, increased blood circulation in the skin, increased parasympathetic activity, increased release of relaxation hormones, and decreased release of stress hormones. Neurological effects mechanism theorized that reflex stimulation would result in decreased neuromuscular excitability, decreased pain, and decreased muscle tension or spasm. The final theory about mechanisms of massage reviewed was psychological effects, which theorized that increased relationship between body and mind would increase relaxation and decrease anxiety (Weerapong et al., 2005).

After reviewing multiple studies testing the validity of some or all of these proposed mechanisms, Weerapong et al. (2005) determined that limited data supports the commonly held belief that massage offers many benefits. Many of the studies were flawed in methodology or were inconclusive, so more research is required to determine which mechanisms are at work in the different types of massage. These results would help determine what types of massage would be most beneficial for a desired response, whether it be relaxation, increased hormone release, or greater muscle compliance.

Effects of Massage on Recovery

One of the detrimental factors of high intensity training bouts is referred to as Delayed Onset Muscle Soreness (DOMS). As Ernst (2008) noted, DOMS is a serious problem that athletes, coaches, and athletic trainers deal with because it causes severe chronic pain and can

decrease athletes' ability to perform due to muscular fatigue, soreness, stiffness, and loss of range of motion. Massage is often used as a treatment for DOMS because of the general consensus that massage increases intracellular lymph flow and blood flow in the capillaries to decrease oedema and reduce pain (Weerapong et al., 2005).

An additional study showed that massage results in greater perceived recovery than no massage between bouts of exercise (Hemmings, Smith, Grayson, & Dyson, 2000). As noted above, however, the physiological effects of massage have not been proven to cause a significant improvement in recovery or performance. This study did show some improvement in blood lactate levels for those participants receiving the massage, but it was not statistically significant.

Another study found that if a client believes the treatment they are receiving will be beneficial, they are more likely to benefit from it than if they do not believe it will work (Kalauokalani, Cherkin, Sherman, Koepsell, & Deyo, 2001). This is the reason for including the placebo control in this study. Comparing the results of the massage and the placebo should give more accurate results concerning the actual benefits of the massage. On a similar note, active recovery combined with massage was shown to be more effective than passive recovery, active recovery, or massage alone on subsequent performance (Monedero & Donne, 2000).

In like manner, muscular recovery is theorized to depend on muscle lactate levels, muscle glycogen availability, delivery of protein and other nutrients for muscular repair after micro-trauma, and speed of oxygen delivery (Weerapong et al., 2005). In addition, massage has been shown to aid in the reduction of primary oedema, which is a result of the initial trauma to the muscles as well as secondary oedema which is a result of the trauma produced by the primary oedema (Weerapong et al., 2005).

Benefits of Resistance Training

Resistance training has many benefits for the general population, but also for athletes training for competition and to improve performance. Long-term resistance training involving progressive overload and the correct speed of movement improve velocity-specific strength (Kraemer, 1994; Behm & Sale, 1993). Increased bone density leading to a stronger frame and decreased chance of osteoporosis later in life is another benefit of resistance training (Kravitz, 1996). Resistance training has been shown to increase heart size in strength-trained athletes by increasing left ventricular wall thickness, left ventricular wall mass, and thickness of the septum wall (Stone, Fleck, Triplett, & Kramer, 1991). Finally, resistance training has been shown to improve glucose metabolism, which would result in better insulin sensitivity and glucose tolerance (Smutok, Reece & Kokkinos, 1993). This has implications for athletes with regard to proper nutrition and diet, but also for diabetic athletes competing.

Once again, the purpose of this study was to determine whether post-exercise massage improves next-day performance after heavy lower body resistance training when compared to placebo control.

Methods of Measuring Force

Force generated by muscles of a particular body part can be measured with various types of force plates, dynamometers, and electromyography for quantitative measurements, and with manual muscle tests and self-reporting for qualitative measurements. Dynamometers are used to measure force by various means just by definition. One hand-held dynamometer that can be used to measure force exerted by muscles is the Nicholas Manual Muscle Tester (Dunn & Iversen, 2003). Athletic Trainers and Physical Therapists use this method of force testing mainly in a

clinical setting to test muscle forces in a very specific muscle group. Another type of force measurement used in clinical and conditioning settings is an isokinetic dynamometer. This is a force measurement that keeps a constant speed of motion regardless of the force output by the muscles and measures force output by the muscle in question. Often the muscles being tested are the flexors and extensors of the knee (West et al., 2005). Isometric peak force measured with a stationary force plate shows the ground reaction force the subject exerts on the plate. In the instance of clean pulls, the more weight the participant lifts, or the more force that is exerted into the ground the greater the force production by the muscles. For the clean pull to be most effective, joint angles and muscle length must be at an optimal level (Kawamori, Rossi, Justice, Haff, Pistilli, O'Bryant, Stone, & Haff, 2006). A final method of calculating muscle force generated is through electromyographic readings. An instrument known as an electromyograph detects electrical potential generated by muscle cells and thereby can determine the amount of force generated by the muscles being tested (Reaz, Hussain & Mohd-Yasin, 2006; Brookham, McLean & Dickerson, 2010).

Biomechanics of lower body lifts

The lift being used for performance measurement purposes in this study is the clean pull from mid thigh. Research shows that the greatest similarity in force production and biomechanics of the hip, knee and ankle extension occur between a squat jump and a hanging clean pull, which would be from the mid shin (Hori, Newton, Kazunori, & Cowan, 2005). For the clean pull to accurately test the muscles that were fatigued in the squat work out, the hip, knee, and ankle must be in a flexed position with the bar positioned at mid shin. The biomechanics of the squat exercise show that the muscles working to make this movement possible include, but are not

limited to: hamstring, gluteus maximum, gastrocnemius, quadriceps, abdominal and spine muscles for stability. This is when the squat is performed in contrast to a solitary open kinetic chain movement or a movement where the limb moving is free from ground contact (Brusal, Lestussi & Parera, 2007).

Method

Subjects

Subjects for this study included males between the ages of 19 and 23 who had been regularly (three times per week) engaging in a resistance training protocol. The subjects were recruited in the Wellness Recreation Center Weight Room. They received a flyer stating the purpose of the study and more information. They responded and were scheduled to participate. The demographic data is as follows: average height with one standard deviation 72.59 inches \pm 2.97 inches, average weight with one standard deviation 197.17 pounds \pm 14.91 pounds., self-reported one repetition maximum [1RM], average with one standard deviation 336.67 pounds \pm 62.42 pounds.

Instrumentation

An AMTI force plate was used in this study to collect data on peak isometric force production for five seconds. The force plate measures the ground reaction forces acting on the surface of the platform. The plate can collect data on various types of forces, but only the vertical ground reaction forces were of interest in this study. The software used in conjunction with the AMTI force plate was Accu Power. The raw data were exported into a spreadsheet software (Excel).

The ultrasound used to carry out the placebo control was turned on, but at a place where the subject could not see that the signal was turned to zero and no signal was being emitted.

Procedures

Before collecting any data, this study received approval from the Institutional Review Board for testing using human participants. All data were collected over a two-day

Day one consisted of participant signing the informed consent and collecting demographic data. Demographic data included height and weight, which was measured using a stadiometer and weight scale respectively. The athlete performed 5-minutes of cycling on a cycle ergometer. Subjects then performed a dynamic warm-up consisting of 10 yards ankle flips, 10 knee hugs (5 each side), 10 yards of butt kickers, and 10 Frankenstein kicks (5 each side). Next, the subject completed the isometric peak force baseline test, heavy lower body resistance training, the isometric peak force post-test and one of two treatments (massage or placebo).

The isometric peak force test procedure was as follows: An Olympic bar was loaded with a weight that each subject will be unable to lift allowing for a maximal isometric contraction. In this case it was 585 lbs. The bar and weight was raised off the ground using boxes so that it would be set for a mid-thigh clean pull. After brief education on form and technique, each subject attempted to exert a maximal isometric effort against the bar for a two second time period while standing on the AMTI force plate. For the pre-test as well as both post-tests, the subject performed a maximal isometric effort, then had one minute of rest before the next attempt. There were three attempts for each test session. The peak force was recorded as Newtons [N]. Data were collected using Accu Power software and saved for further analysis.

The training protocol for heavy lower body resistance was based on the basic back squat lift and consisted of a warm up of 10 repetitions [reps] at 30% of their self-reported one repetition maximum [1RM], 10 reps at 50% of their 1RM, and 4 sets of no more than 12 reps at 67% of their 1RM. The participant was allowed to stop short of the 12 reps, but was required to stop at 12. The treatment group received a ten-minute massage focusing on the muscles of the lower body. All massages were conducted in a similar manner by the same licensed massage therapist. The massage was conducted in the following manner:

Table 1: Massage Technique Used for Treatment

Massage Technique	Description	Grade
Warm-up Effleurage	Stroking multi-directional	Grade 1
Stripping	Palm of hand or closed fist; insertion to origin	Grade 1 up to Grade 2
Kneading	Whole hand two handed; centripetal and centrifugal	Grade 2

This was performed to the following muscle groups: hamstrings, quadriceps, gastrocnemius, soleus, IT Band, and Achilles tendon. The massage finished with a deep myofascial massage applied to the calf areas bilaterally, and grade 1 effleurage to all muscle

groups as a cool down. The massage medium was a standard massage lotion used for sports injury massage. The control group received 10 minutes of ultrasound treatment (with zero signal emission) on the same muscle groups.

On day two, the participant completed the same dynamic warm-up that was performed on day one of testing. Then the second isometric peak force posttest was administered. Once the study was complete, the participant was debriefed on his or her participation in the study using a debriefing script talking about the deception occurring in the study as well as the necessity of this deception for the study to be effective. The deception was that the participant in the ultrasound group did not receive a true ultrasound. The machine was turned on, and the lotion was applied to the participant's skin as a medium for the waves to travel through, but the signal of the ultrasound was kept at zero. The mechanism by which ultrasound works is through soundwaves, thus making the ultrasound the participants received nothing more than the wand lightly touching the skin. This script used for debriefing is in the appendix section.

Experimental Manipulations

The force plate used to collect data for this study was not available during the spring semester, so data was collected in the summer months. As an experimental manipulation, instead of spreading the data collection out 7 days so a One Repetition Maximum [1RM] could be tested, the participants self-reported their 1RM. This may have caused under-reporting of the 1RM so that more could be lifted during the squatting protocol, but fatiguing of the legs would not happen as severely due to lower weight being lifted. Another possible problem this could pose is over-reporting their 1RM, which would only allow them to do a very small number of the repetitions necessary to properly fatigue the muscles of the lower extremities.

Another manipulation made to the study was that a greater sample size was preferred, but due to the short time allotted for this study in addition to the force plate being unavailable for the spring semester, the sample size was small. Instead of the preferable 8 participants or more in each group, there were 4 in the massage group and 2 in the placebo ultrasound group.

Results

The results of this study were not statistically significant. On average, the participants receiving the massage improved slightly from their post-lifting mid thigh pull to their next-day mid thigh pull. The first peak force and the average of force in Newtons for the next half second is what the results were based on. These participants experienced a drop in their force production as measured by the AMTI force plate during the mid-thigh pull from before to after the heavy lifting protocol.

The participants receiving the ultrasound underwent an increase in force generated by the mid-thigh pull from before to after the heavy lifting workout, and they underwent another increase between the post-exercise pull and the next-day pull.

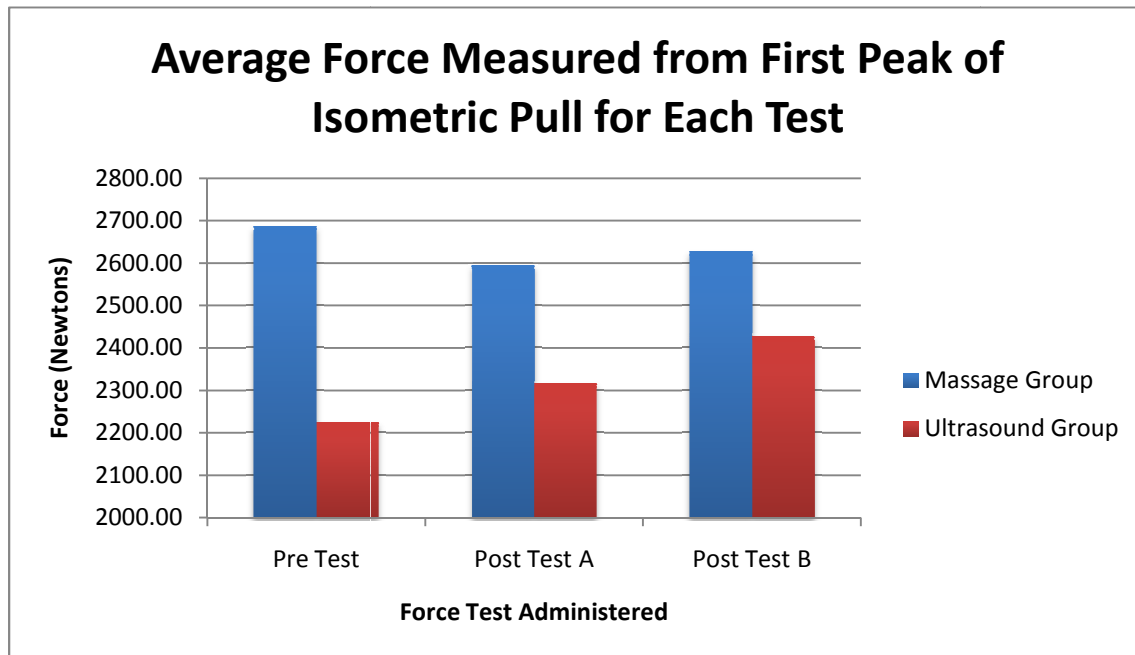
The null hypothesis to be tested was that there would be no significant difference between the massage group and the placebo control group in regards to peak isometric force production following a bout of heavy lower body resistance exercise. There was no statistical significance found in this study so more research is required to further address this null hypothesis.

Data Analysis

There were four participants who received the massage treatment and two participants who received the ultrasound control treatment. The data were analyzed in two ways, the first

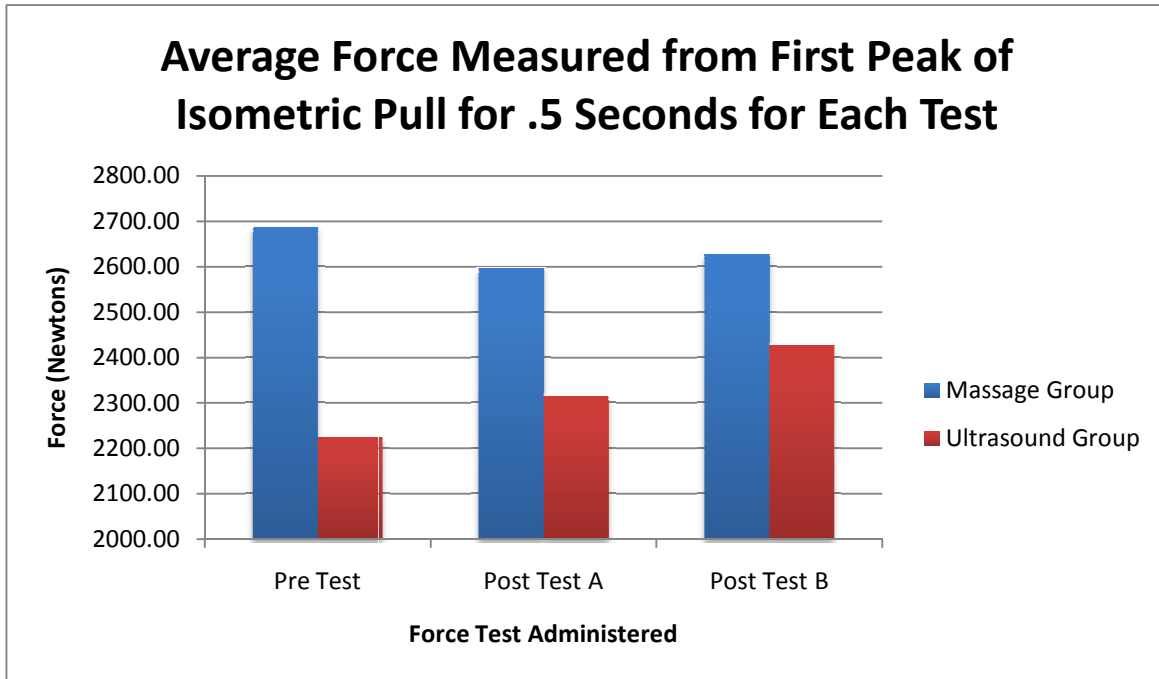
peak of the isometric pull was established by the data and the three trials for each test (pre, post A, and post B) were averaged for each participant. These averages were then averaged for each test giving an overall picture of the trend.

Chart 1: Average Force Measured from First Peak of Isometric Pull for Each Test



The second way the data were analyzed was finding the first peak force and averaging that force with the forces collected every .005 seconds for half of a second for each person for each test. These averages were then averaged together for each test to show the trend. The reason the average over .5 seconds was one method of data analysis is because the first peak could be an extremely high or low number that would be balanced out by carrying out the average for 50 readings.

Chart 2: Average Force Measured from First Peak of Isometric Pull for .5 Seconds for Each Test



Discussion

The massage and placebo effect was measured in terms of performance on the Isometric Peak Force Test completed three times by each participant. Each subject performed a pre-test, a post-test on the same day as the heavy training protocol, and a next-day post-test with three trials for each of the three tests. The results were measured using: peak force (Newtons), defined as the first peak force produced by the subject, and average peak force, defined as the average of force produced starting at the first peak and continuing for the next .5 seconds. The null hypothesis was that there would be no difference between the massage and ultrasound control groups with regard to difference in peak force generated in the pre-test, post-test A (after the heavy lifting protocol), and post-test B (the following day after receiving one of the two treatment options).

Limitations

The first limiting factor for this study was the sample size available due to a limited time frame for the study to be completed. The study only had six participants with four in the massage

group and two in the ultrasound control group. This small sample size left little room for an erroneous performance for any reason because each trial was a very large portion of the data collected.

Another limiting factor that worked against the validity of the study was that the mid-thigh pull, which was used to collect force data, was not a good representation of the muscles that were being fatigued in the heavy squat protocol. Biomechanically, the back squat fatigues the quadriceps, hamstrings, gluteal musculature, gastrocnemius, and the soleus. The pull the participants performed had the bar positioned at mid thigh. This height of the bar did not restrict the muscle groups activated as well as a lower pull would have. The higher pull allowed for the participant to compensate for the fatigue in the legs by using more of the back and torso muscles to generate force, which could account for the lack of statistical significance found in the data analysis. If the bar were positioned lower, the participant would be required to use his lower body musculature including: hamstrings, gluteal musculature, quadriceps, gastrocnemius and soleus to generate force (Braidot, Brusal, Lestussi, & Parera, 2007).

Possibly limiting the amount of force generated by the participants was the sweat on their hands reducing the grip they could maintain on the bar during the pull. Having chalk available to all the participants from the beginning so they could apply it to their hands if they felt they did not have good contact with the bar could have helped counteract this limitation.

A limitation for some participants could have been that the warm-up before pulling in the pre test was only 5 minutes on the cycle ergometer and a short dynamic warm up. For some of the participants, the force generated on their pull increased greatly from the pre-test to post-test A. The limiting factor could be that the warm-up did not incorporate any lifting and the data

analysis assumed a maximal effort from the start. This could have been one reason the pre-test data seemed to be low. In addition, often after the heavy lift, the participants noted feeling stronger so whether psychological or because they felt warmed-up, the second lift was better for some of them even though it should have been much lower due to muscular fatigue.

The final limitation to be discussed here was that due to time constraints and participant availability in the summer, the testing of the 1RM was removed from the study and the participants self-reported their 1RM for squat on the day of testing. If the participant has not tested his 1RM recently, it could be off significantly due to changes in training protocol or other variables. If the self-reported 1RM was too high, the participant struggled in completing the training protocol used to fatigue the muscles of the lower extremity.

Suggestions

Suggestions for further study include:

1. Using a larger sample size so each test does not carry as much weight.
2. A clean pull that is set up with a more biomechanically accurate height so that joint angles stress the appropriate muscle groups (most likely a pull from mid-shin).
3. Having chalk or a towel available for the participants to dry their hands before each pull attempt so maximal effort can be used each time.
4. A warm-up involving both the dynamic warm-up and a small lifting warm-up before the first round of Isometric Peak Force tests are conducted.
5. Allow the participant to try a pull at 50% effort before the data collection begins so he can learn how it should feel before the actual testing begins.

6. Having the participant come in 5 days before testing begins to determine his 1RM scientifically instead of having it self-reported.

Conclusion

While the data collected was inconclusive, the recommendations suggested for future studies will be paramount as this study is continued. The use of the placebo ultrasound to balance the physiological and psychological factors of next-day performance after a heavy resistance workout is paramount in the validity of this study. However, at this time, the question of whether massage is an effective way to improve next-day performance still stands. This method of testing has potential to be very effective if the suggestions made in this paper are followed and future research is conducted with a larger sample size and a clean pull force test with the bar positioned at mid-shin instead of mid-thigh.

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Appendix

Recruitment Script

My name is Kristin Iehl, I'm studying Exercise Science at the University of Northern Iowa. I am doing a research project on whether massage or ultrasound after a heavy lower body resistance workout results in better next-day performance. Participating in this study is voluntary and any gathered information will be kept confidential. If you are a male or female between the ages of 18 and 25 who has been resistance training for the last 6 months you are eligible.

If you would like to participate in this study please contact me at *Phone number*.

*Contact information will depend on who is recruiting the participant.

Recruitment Flyer

Massage Study Participants Needed

Participate in a study of the effects of massage on next-day performance.

You are eligible if:

- You are between the ages of 18 and 25
- You have been involved in a consistent resistance training program for the past 6 months

If Interested Please Call _____ at _____. Please leave a name and phone number I can reach you at.

Debriefing Script

Thank you for participating in this study. This study required the use of deception for the participants undergoing the ultrasound treatment. The deception occurred as the placebo group participants received an ultrasound at zero intensity, but were not told this information. This was necessary because perceived recovery has been shown to be a very important factor in evaluating the value of massage as a recovery tool. If we have similar results from the placebo and treatment groups it will show that the benefits of massage regarding performance are mostly psychological. If you have any questions, please ask. And thank you again for participating.